FG03-93ER25163

DOE/ER/25163--T2
CONF-970515--1

3.2 APPENDIX II

Beam Steering and Routing in Quadratic Nonlinear Media

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Abstract

We show how the spatial phase modulation of weak second-harmonic signals controls the overall direction of propagation of spatial solitons in quadratic nonlinear media. We investigate numerically such a process and discuss its applications to all-optical beam routing

Self-action of light is a subject of constant investigation due to the fascinating phenomena encountered and their potential applications to all-optical signal processing devices. Optical solitons, both temporal and spatial, play a central role in such scenario because of their unique particlelike properties. Here we study the spatial case. Until recently, optical solitons and their applications have been pursued using the Kerr effect in cubic nonlinear media and the photorefractive effect. However, solitons (more properly, solitary waves) also form in quadratic nonlinear media, hereafter referred as $\chi^{(2)}$media.[1] Solitons in quadratic nonlinear media exist in a variety of wave and material conditions and they have been observed experimentally in bulk media and in planar waveguides.[2]

Our goal in the present communication is the investigation of the steering control of optical beams based on the excitation of spatial solitons in quadratic nonlinear media.[3,4] We investigate a configuration in which steering of a strong fundamental beam travelling in a planar waveguide made of a $\chi^{(2)}$ nonlinear material, such as $LiNbO_3$ or KTP as the guiding medium, is achieved by injection of a weak second harmonic wave with a spatial phase modulation. The simplest situation corresponds to a tilted second-harmonic input beam that hence enters the waveguide forming an angle θ with the input fundamental beam. Figure 1 shows such a set-up. The fundamental and second-harmonic beams, which in the low-power or quasilinear regime would propagate in different directions, mutually trap and lock to each other, and form a spatial solitary wave. Under such conditions the two beams propagate stuck to each other along the waveguide, with the strongest beam dragging the weaker, in such a way that the output position of the beams at the end face of the waveguide can be controlled by a variety of ways. Figure 2 shows the typical result of our numerical simulations: the plots show the output

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position of the solitons as a function of the tilt of a weak second-harmonic beam launched together with a strong fundamental beam, in a representative case in terms of input power and material conditions.

In this communication we report the results of our comprehensive numerical and analytical investigations of the beam steering process. We study the dynamics of the beam steering and how the output positions of the solitons can be controlled by the input light and waveguide conditions, including the wavevector mismatch and Poynting vector walk-off between the waves, for different phase-modulation schemes.[5]

References

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Figure Captions

Figure 1. Set-up scheme showing the directions of the fundamental and tilted second-harmonic beams in the quasilinear regime ad the direction of the soliton.

Figure 2. Position of the soliton peak for two different values of the wavevector mismatch. Upper curve $\beta = 10$, lower curve $\beta = 3$. The power of the second-harmonic input wave is 5% of the total power in both cases.

Figure 3. Details of the beam propagation under typical excitation conditions. The deflection of the beam is clearly visible.

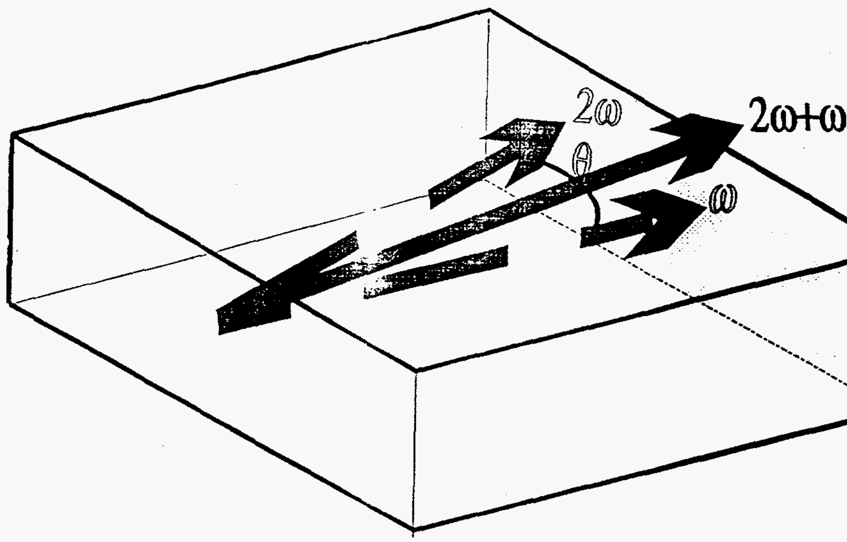

Fig 1

Fig. 2

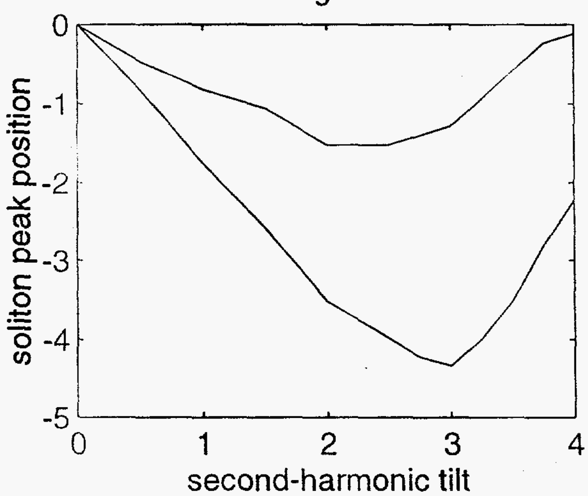

Fig. 3